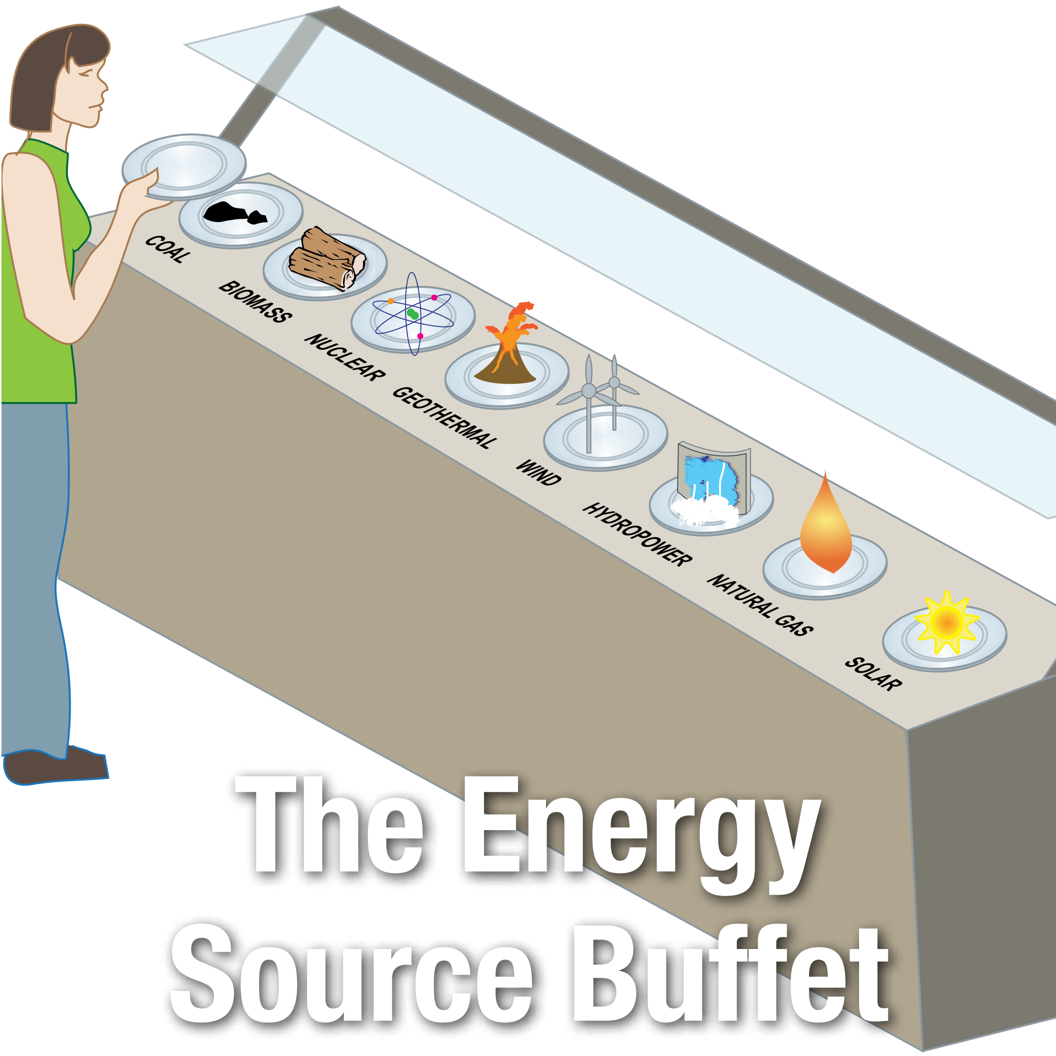

The Energy Source Buffet

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California Education and the Environment Initiative
Science Standard 6.6.a.

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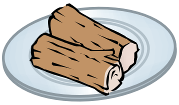
Introduction

Everyone loves a buffet, a spread of food with lots of tasty choices. We are fortunate in California. We have eight sources of energy, the “dishes” in our energy source buffet: coal, biomass, nuclear power, geothermal power, wind, hydropower, natural gas, and solar power. Each utility company and community takes a “plate” and chooses how much from each source it will use. These choices depend on the costs, benefits, and availability of different sources. Your community has taken a little bit from several of these sources to feed your everyday needs for electricity and heat. California law states that a portion of these sources must be renewable.

You may have heard the saying: “There’s no such thing as a free lunch.” The Energy Source Buffet focuses on the cost of getting and using energy. This booklet tells how each energy source is used, where it comes from, and how it affects the environment. You will learn that we have to pay for the buffet—the costs of extracting the energy and how using each energy source influences our environment.

A later lesson will look at the benefits of using each of the different energy sources. It will also help you learn how to weigh the costs and benefits of our energy choices. You will discover that, like at every buffet, we have many options to choose from.

Enjoy the buffet.



Biomass

The word root "bio" refers to living things. So bioenergy is energy that comes from plants and animals. Plant and animal parts are called biomass. Biomass can be burned to produce electricity. Biofuel is fuel created from biomass. This fuel can be used in cooking, heating, and transportation. For example, firewood is a biofuel.

How we use the energy in biomass

People burn biomass to release heat. The heat released from burning biomass is used to turn water into steam. This steam is used to turn a turbine that is connected to a generator that produces electricity. Biofuels can be used in engines to power cars. They can also be burned for cooking and heating.

Firewood

Where we get biomass

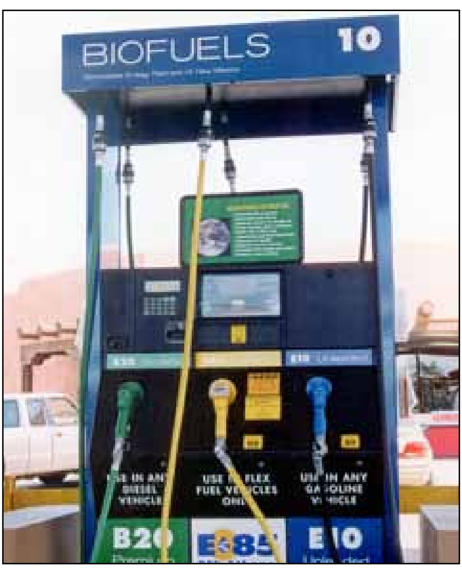
The most common forms of biomass are wood and other plant parts. Many people use firewood for heating. People even burn sawdust and wood shavings. Processed fruit pits can be made into charcoal. People can also burn corn cobs and rice stalks to produce energy.

Solid waste is another important source of biomass. Think about what you put in the garbage. Much of it could probably be dried and burned. In fact, a ton—2000 pounds (907 kilograms)—of garbage can yield as much heat energy as about 500 pounds (227 kilograms) of coal!

Ethanol, a liquid made from crops like corn, sugarcane, and sugar beets, is a type of biofuel. Even grass, sawdust, and yard clippings can be used to make ethanol.

“Biodiesel,” is made by chemically altering vegetable oils. It can also be produced from plants, such as sunflowers, and even algae.

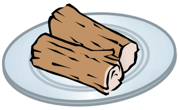
Methane gas is another type of biofuel. Decaying (decomposing) plant and animal matter naturally produces methane. People can capture and store methane, like any other gas, in tanks or canisters. Methane can be burned to produce heat. (Note: Natural gas is mostly methane that was formed long ago and trapped underground in pressurized reservoirs.)



Triple biofuels dispenser

Byproducts and effects of using biomass

When anything burns, byproducts enter the atmosphere as gases,



smoke, and particles that contribute to air pollution. One important byproduct of burning biofuels is carbon dioxide. For example, whenever you burn firewood for a campfire or in a fireplace, carbon dioxide is released into the atmosphere. Carbon dioxide in the atmosphere traps Earth's heat. More carbon dioxide can lead to warmer temperatures on Earth.

Carbon dioxide tends to stay in the air. Other byproducts, like particles of soot and ash, may fall to Earth with the rain. Burning biomass is cleaner than burning coal, but it still contributes to air pollution. It also releases heat into the atmosphere.

How using biomass changes natural systems

Some types of biofuels are made from crops. Farmers often use pesticides and fertilizers to help grow these crops. Pesticides and fertilizers can enter natural systems if rain washes them into streams or lakes. They also enter the ground water through the soil. Growing crops for fuel also takes a lot of land. The farmers then cannot use the land to grow crops for food. Growing corn to produce ethanol for biofuel might reduce our use of oil but it would use a lot of farm land. Converting the corn to ethanol also uses a lot of energy.

Corn alcohol (ethanol) banner

Another form of biomass that can be used to generate power is waste. Many landfills in California are filling up. As these landfills fill up, communities have to use new areas for waste disposal. Burning waste can help get rid of garbage that would otherwise fill up landfills. Some of that waste might also produce water pollution. Thus, burning waste for energy can also help reduce water pollution.

Biomass plant in northern California

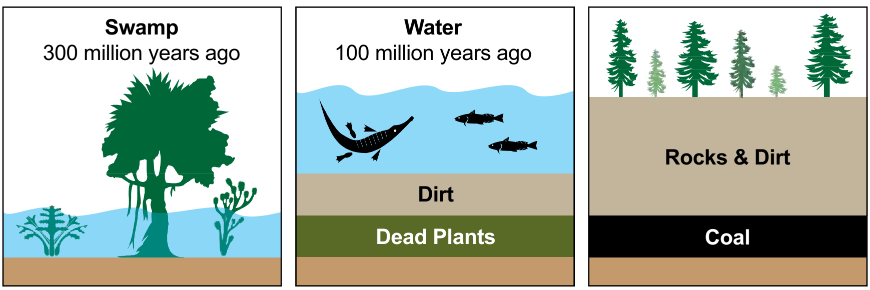
"Waste-to-energy" plans have not gained much support in California. This comes from concerns about smog and air pollution. People want to keep California's air clean by supporting our high air quality standards, the highest air quality standards in the nation. Therefore, it is hard to convince communities to accept the burning of waste because of their concerns that byproducts will be released into the air.

The methane gas that comes from decaying plant and animal matter offers another option. Many cities collect the methane released by the decaying garbage in landfills. They sell the methane they collect to businesses and nearby power plants.

Coal

Coal is a mineral formed from plants and animals that died hundreds of millions of years ago. That is why it is called a “fossil fuel.” Soil and water covered the plant and animal matter. This matter decomposed and, over millions of years, heat and pressure changed it into coal and other fossil fuels, such as petroleum and natural gas.

Coal Formation



Before the dinosaurs, many giant plants died in swamps.

Over millions of years, the plants were buried under water and dirt.

Heat and pressure turned the dead plants into coal.

How we use the energy in coal

Burning coal releases its energy. In the past, many people burned coal in fireplaces and furnaces to heat their homes. Factories, such as steel and iron mills, used the heat from burning coal to melt these metals.

Today, utility companies burn coal to make steam

Trainload of coal

that they use to drive electric generators. In the United States, about 92% of the coal we use goes to produce electricity. Coal provides about half of the electricity used in the United States each year. In California, this percentage is much less. Only 16.6% of our electricity comes from coal. This electricity gets purchased from power plants that are found in other states.

Where we get coal

Coal deposits form layers, called “seams.” These seams may be hundreds of feet thick or less than an inch thick. The seams of coal can be near the surface or hundreds of feet underground. If the coal is near the surface, open pit and other surface mining methods are used to remove it. Miners use explosives and machines to remove the rock and soil that cover the coal seams.

About one-third of the coal mined in the United States requires underground mining methods. This type of mining is much more expensive and dangerous than surface mining. Underground mines use long tunnels and shafts to reach the coal seams. Coal is mined in


Underground coal seam on fire

several regions in the United States. Wyoming and West Virginia are the biggest coal-producing states. There is little coal found in the state of California, and there are no coal-burning power plants.

Coal miners at work

Byproducts and effects of using coal

Burning coal produces many byproducts. A variety of chemicals enter the air. Carbon dioxide is one of the gases released into the air. Carbon dioxide in the atmosphere traps Earth's heat. More carbon dioxide can lead to warmer temperatures on Earth. Sulphur dioxide gas and nitrogen oxides are others. When nitrogen oxides enter the air, they react with sunlight, creating smog. When sulfur dioxide mixes with rain, sulfuric acid falls to Earth. Burning coal also releases other unhealthy particles into the air.

Strip coal mining near Riohacha, Colombia

Burning coal also produces solid ash. This ash is toxic. It contains chemicals like arsenic, lead, and mercury. It is also radioactive. Wind and water can carry ash from burning coal into streams and the surrounding environment.

How using coal changes natural systems

In surface mining, soil is removed from above the coal. Now, the government requires coal mine operators to put this soil and rock back after they have taken out the coal. The plants and animals in the area may take many years to return.


Coal miner shoveling coal

Coal mining releases large amounts of dust. When this dust gets into miners' lungs, it can cause "black lung disease." Modern coal mines use many methods to reduce coal dust, but it is still a problem. The coal dust can also reach streams and get in the air. There, it can affect plants and animals, including humans.

Also, acid rain can be caused by the gases released into the air when coal is burned. Acid rain can damage plants and dissolve minerals in soil. As this water reaches lakes and streams, animals and plants may no longer be able to live there and people cannot use this water.


Trees affected by acid rain

Geothermal Power

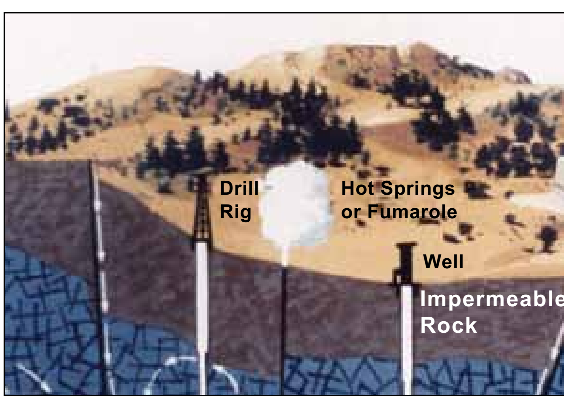
Have you ever heard of Old Faithful in Yellowstone National Park? If you know about this geyser, then you know something about geothermal energy.

The word root "geo" means Earth. "Therm" means heat. Geothermal power is heat that comes from Earth.

Earth's surface, or crust, is a thin layer broken into pieces called plates. In many places, pockets of molten rock are near Earth's surface. In some places, this molten rock, or magma, lies beneath cracks in the crust. This magma is under a great deal of pressure. It can flow to Earth's surface and form a volcano or lava flow. In other places, smaller cracks allow water to enter the rock above "pockets" of magma, and the magma heats the water. This creates a reservoir of hot underground water. The water can get hot enough to turn to steam. In some places it reaches the surface and forms geysers like Old Faithful.

How we use geothermal energy

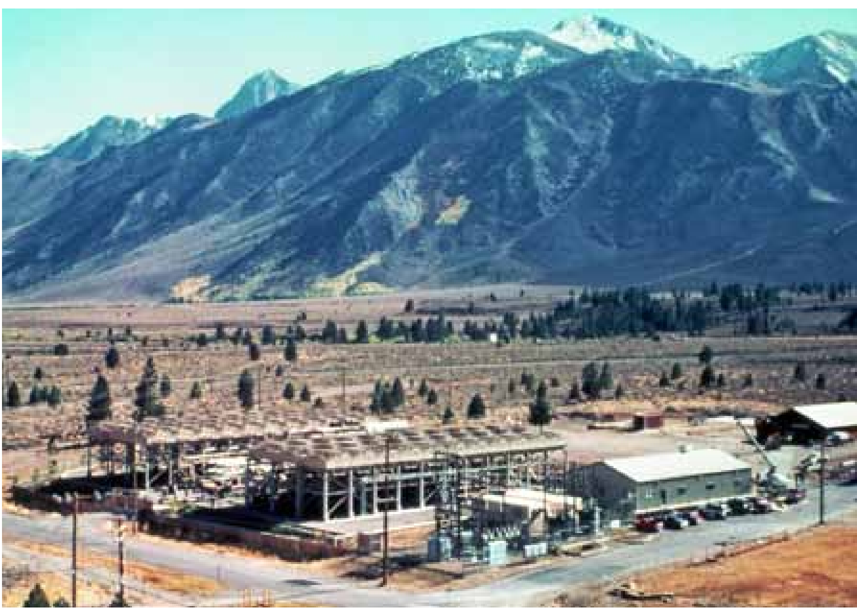
The same energy that can send the water in a geyser 400 feet up in the air can turn a turbine that generates electricity. Geothermal power plants all use heat from Earth to produce steam. These plants use the steam to turn turbines that power generators and produce



Geothermal energy

electricity. The largest complex of geothermal power plants in the world is located at The Geysers, near the town of Middletown in northern California. This site does not have any actual geysers, but it has a very large basin where the hot water is trapped under rock.

Making electricity is just one of the uses of geothermal power. Naturally warm water can heat greenhouses and fish farms. The warmth makes both plants and fish grow faster! Industries use heat from geothermal water in many ways, from washing wool to making paper. In some places, geothermal power heats homes and other buildings directly. San Bernadino, California, has one of the largest systems in the world that uses geothermal energy to provide heat and hot water to local customers. Hot springs also provide the mineral-rich water at many spas.



Mammoth Pacific geothermal power plant, California

Where we get geothermal power

Drilling a well provides access to reservoirs of geothermal water near Earth's surface. When the well reaches the geothermal reservoir, hot water and steam rush out. They come out with enough force to turn a turbine that powers a generator. After the water cools, an injection well pumps it back into the ground. Magma reheats this recycled water and produces more steam.

Byproducts and effects of using geothermal power

Geothermal power plants use natural steam and heat. When the steam at a geothermal power plant passes through Earth's crust, it dissolves some minerals and other chemicals. The power plant removes some of these chemicals as it uses the steam. Other chemicals remain in the steam that goes into the air. When the steam cools and forms water droplets, those chemicals can fall to the land. They also fall into streams and lakes.

The Geysers geothermal power plant, California

Power plant operators may use the chemicals removed from the hot water if they are safe to use. Liquid fertilizer is one use for these chemicals. Other uses of byproducts are being studied. Some of the minerals and chemicals are harmful, so operators must store them safely. Improperly stored chemicals can leak into the soil or groundwater near the power plant.

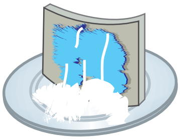
Some of the chemicals, such as sulfur, can cause water pollution if they get into streams. If deposited on the land, some chemicals may kill plants and animals. However, these effects are much less than those from power plants using other sources of energy, such as fossil fuels or nuclear power.

Hot water is another byproduct of geothermal power. As noted in the previous section, hot water has many uses.

How using geothermal power changes natural systems

Power plant operators pump some hot water back underground to create new steam. They call this process recharging. Some geothermal power plants recharge using wastewater from nearby cities. This use prevents dumping of the wastewater into streams.

A power plant may dump hot water into a local lake or stream. When this happens, the hot water warms the water in the lake, pond, or stream. The warmer water can cause fish and plants to die. Scientists call this “thermal pollution.” However, the U.S. Clean Water Act requires that thermal pollution not harm the plants and animals in the surrounding waters.



Hydropower

Have you ever used water to spray leaves off of a driveway or to wash a car? Have you ever waded into a stream or the ocean and felt the water pushing at your legs? Flowing water has a lot of force. It can wash dirt from a car windshield, move a floating stick down a creek, or wash away buildings and trees in a flood or hurricane. Given enough time, water can even erode away a mountain. “Hydro” means water. Hydropower can come from fresh or salt water.

How we use the energy in water—hydropower

Water can move things, clean things, wash away soil, and carve into rock. Ancient people discovered that if they built a wheel that caught the moving water in a river, the wheel would turn. The moving wheel could then power a machine. Early grain mills and lumber mills used hydropower to grind wheat and cut wood. This explains why such mills were all built near rivers. Today, we use the moving water in rivers to turn turbines. The turbines power generators that produce electricity.

Where we get hydropower

As in olden times, the best place to get hydropower is in a river. The amount of water in a river changes during different seasons and as the course

Aerial view of Hoover Dam, Nevada

of a river changes. Utility companies want to have the same amount of hydropower all year round. Therefore, they build large dams across rivers. The dams create reservoirs that hold enormous amounts of water. Within the dam are huge pipes, called penstocks. Dam operators release water in the reservoir through the penstocks. As the water flows through a penstock, it turns a turbine. The turbine connects to a generator that produces electricity.

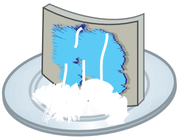
Natural rivers are not the only places to find moving water. Storm water channels and aqueducts also provide hydropower.

Ocean tides also move huge amounts of water every day. In some places, the power of tides drives electric generators. Ocean waves also produce a a great deal of force. Currently, wave and tidal power are only used on a small scale. Scientists and engineers are studying better ways to harness the power of waves.

Byproducts and effects of using hydropower

The primary purpose of hydroelectric dams is to store water used to generate electricity. A lake, or reservoir, holds the water. A reservoir has other uses. For example, people may enjoy recreational activities on the lake. They may boat, swim, or fish there.

But, building a dam across a river changes the environment upstream and downstream from the dam. Less water flows downstream. This helps with flood control, but changes the natural processes of erosion and sedimentation, and can change the downstream water temperature. The water stored behind the dam floods the land upstream. This flooding takes away habitat from both animals and plants.



Water flowing in rivers carries mud, sand, and rocks. Reservoirs slow or stop the water, and these particles, small and large, settle out and form sediments behind the dam. These sediments once traveled down the river. As they did so, they supplied the river banks with sand and soil. They also deposited nutrients in the river bed, on river banks, and in floodplains. Dams prevent this from happening.

Dams also change the water temperature in the river. The Sun's heat may raise the temperature of dammed water more quickly than that of fast-flowing water in the river. When the water goes through the penstocks in the dam, it is warmer than the plants and animals downstream normally experience. Also, the dam may slow the river flow downstream, enabling the Sun to heat it more than if the dam were absent.

How using hydropower changes natural systems

Even small changes to river flow or water temperature can have big effects on all other parts of the river's natural

Lake Oroville and Dam, California

system. High water temperatures can harm the fish and other living things in and around the river.

Some fish, such as salmon, must move to different parts of the river to complete their life cycle. Adult salmon swim upstream from the ocean to breed and lay their eggs. Young salmon that hatch in the river must swim to the ocean before becoming adults. A dam can prevent them from doing this. Dams also affect the places where salmon usually lay their eggs.

Many people like to fish, boat, swim, or water ski in reservoirs created by hydroelectric dams. Roads and parking lots must be built so that people can use the reservoir. This reduces the natural habitat for plants and animals.

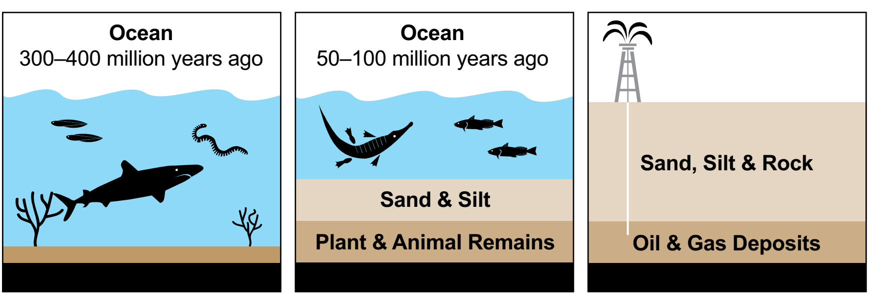
W.A.C. Bennett Dam and Gordon M. Shrum Generation Station, British Columbia, Canada

Natural Gas

Millions of years ago, tiny sea plants and animals died. They sank to the bottom of the oceans. Over time, thousands of feet of sediment covered the dead plants and animals. Ocean sediment turned into rock. The pressure and heat from the layers of rock caused the plant and animal matter to decompose and change, producing pockets of natural gas and other fossil fuels, such as petroleum. Petroleum is also called crude oil. Natural gas is very light and would have escaped into the water and then into the atmosphere, but the rock layers trapped it. This is how natural gas deposits formed long ago. Many of these deposits are now underground.

Natural gas is colorless and odorless. Natural gas is a mixture of many different gases. The main ingredient is methane. It also includes propane, butane, and ethane gases. Since the natural gas we use formed millions of years ago, it is called a “fossil fuel.”

Petroleum and Natural Gas Formation



Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.

Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.

Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and gas deposits.

How we use energy from natural gas

Burning natural gas releases heat. Factories use about 50% of the natural gas collected in the United States. Homes and businesses use another 35%. They use the gas for cooking and heating homes and water.

Natural gas well

Power plants burn the remaining 15% to power generators. Pumps force the gas into the power plant through large pipes. Smaller pipes connect to the large pipes. At a certain point, the gas is burned to boil water into steam to turn a turbine that powers a generator and creates electricity.

Natural gas plume on platform

Where we get natural gas

People get more than 90% of the natural gas they use by drilling wells. Many times, natural gas is found near coal mines or crude oil wells. These deposits may be on land or under water. Either way, a well is drilled to get to the gas.

Once the drill hits the trapped gas underground, the gas shoots upward to the surface. Pumps and pipes collect the gas and move it to a refinery. The refinery takes out water and other chemicals and separates the methane from the other gases, such as propane and butane. The refined gas goes to stores, factories, and power plants in tanks or through pipelines.

Byproducts and effects of using natural gas

Burning any fuel, including natural gas, releases chemicals into the air. One of these chemicals is carbon dioxide. Carbon dioxide in the atmosphere traps Earth's heat. More carbon dioxide may lead to warmer temperatures on Earth.

The refineries that separate natural gas so it can be used as a fuel also release chemicals into the air. One of these chemicals is a dangerous gas called hydrogen sulfide. Hydrogen sulfide can damage nervous and respiratory systems. Still, the effects of burning natural gas are much less than the effects of using other sources, such as coal.

Natural gas power plant, Ventura, California

Power plants using natural gas have tall chimneys. These chimneys release the byproducts 10 or 12 stories up in the air. At the end of those chimneys, any natural gas left over is burned off to reduce effects on natural systems.

Natural gas can also contain harmful chemicals, such as mercury and radon. Breathing the gas is very dangerous. Refineries must safely collect and store these chemicals so that they do not leak into the soil, water, or air.

How using natural gas changes natural systems

Drilling wells for oil and natural gas disrupts the land in the area of the well. Whatever plants and animals lived in the area lose their habitat.

Natural gas is highly flammable, meaning it burns easily. It can be dangerous if it is not stored properly or if there is a leak. If heated, the gas will explode. Since natural gas is colorless and odorless, a chemical that makes it smell is added to the gas before it leaves the refinery. In case of a gas leak, the odor warns people of the danger.

Natural gas refinery, Bonny Island, Nigeria

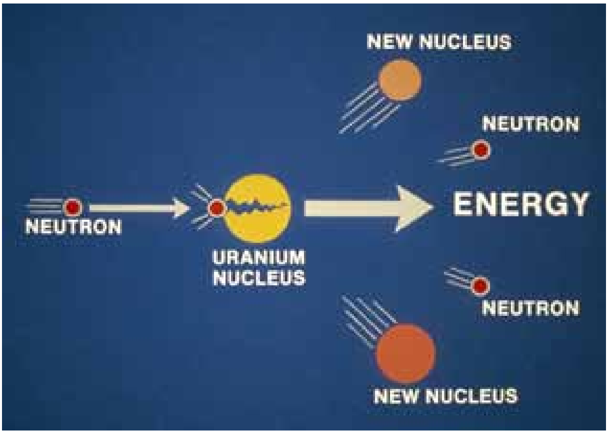
Nuclear Power

Atoms make up everything on Earth. There are many different kinds of atoms. The smallest is hydrogen. The largest naturally formed atom is uranium. The center of an atom is the nucleus. The nucleus of an atom is made of particles called protons and neutrons. Breaking apart the nucleus of an atom releases a lot of energy. Breaking apart is also called fission. Nuclear power results from a fission reaction in a nuclear reactor.

An atom of uranium-235 has 92 protons and 143 neutrons. If the nucleus breaks apart, the protons and neutrons fly apart in different directions. The protons and neutrons fly off with great force. The nuclei of any uranium atoms in the area break apart when hit. Each nucleus then releases still more protons and neutrons. The result is a chain reaction that produces huge amounts of heat, light, and other energy.

How we use nuclear energy

Nuclear power plants create and use these chain reactions in a controlled environment. The heat released by the breaking of atoms in a nuclear reactor heats water to make steam. That steam turns turbines connected to generators. The generators then produce electricity.



Uranium fission process

Where we get nuclear power

Uranium ingots

Power companies use uranium in their nuclear reactors. Uranium exists in rocks all over the world. Some rocks have more uranium than others. Rocks rich in uranium are not very common.

The rocks with uranium are mined and then crushed and mixed with an acid. The acid separates the uranium from other chemicals in the rock. Pellets made from the uranium fuel the nuclear reactor at the power plant.

In the reactor, neutrons from uranium atoms bombard the other uranium atoms. When hit, the atoms split apart. This releases more neutrons and energy.

Diablo Canyon nuclear power plant, California

Byproducts and effects of using nuclear power

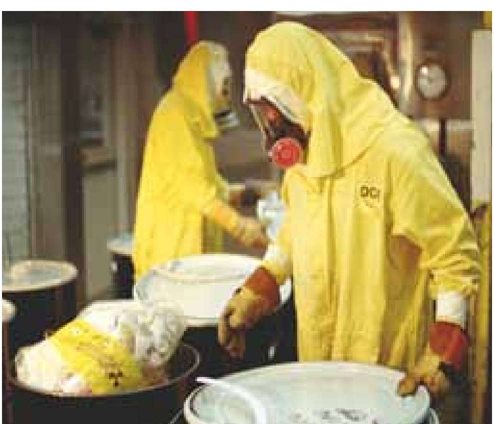
Splitting uranium atoms creates a lot of energy. Energy continues to be released a long time after the reaction is over. Some leftover materials in the reactors are radioactive. This means that they release, or radiate, dangerous levels of energy. Uranium itself is naturally radioactive.

Like all large power plants, nuclear power plants use water. Some of the water becomes steam, which turns the turbines. Nuclear power plants also use a lot of water to cool their equipment and buildings. This explains why utility companies build power plants near rivers, lakes, or the ocean.

Some nuclear power plants put hot water from the cooling process back into the rivers, lakes, and the ocean from where it came. This hot water changes the temperature of the water. The warm water may harm plants and animals. Other power plants use the water in cooling towers. These do not heat up the water source, but use up more water.

At uranium ore mines, rock that does not have much uranium in it is left at the mine site. Unless it is reburied, the radioactive uranium can harm wildlife. It can also enter the water or air and be dangerous to people.

Materials that become radioactive because of the reactions at the power plant release dangerous levels of radiation. They emit radiation into the environment for many years. Power plants can re-use some of these materials. Others must be safely stored until the energy being released is no longer dangerous to living things. That could take hundreds or thousands of years.



Containing nuclear waste

Accidents have happened at nuclear power plants. These can cause the release of radioactive materials. Such an event can kill people and poison the environment for years to come.

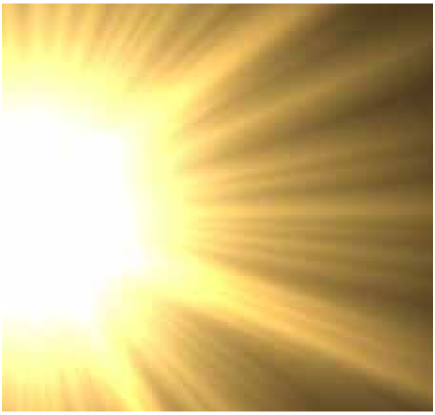
How using nuclear power changes natural systems

Like all mines, uranium mines take over areas where plants and animals live. Once all of the uranium is mined, it takes years for the area to return to a safe habitat for plants and animals. If not handled properly, the radioactive waste products from the mining can harm living things for many years. Acids and other chemicals used to process the uranium at the mine site can make the soil and water in the area unhealthy if mine operators are not careful.

The U.S. government has been working on ways to ensure that the radioactive waste from nuclear power plants is safely stored for hundreds or even thousands of years. It has built special waste storage facilities far away from our cities and towns. Inspectors must check the storage facilities frequently to make sure that no radioactive material leaks out.

Uranium mine, Arizona

Solar Power


Visible solar energy

The Sun radiates light into space all the time, in all directions. Some of that energy reaches Earth. Some of it we can see and some of it we cannot. Everything, whether it is a solid, a liquid, or a gas, is heated by the Sun. If sunlight falls on it, it gets warmer. This is solar energy.

How we use energy from the Sun—solar power

You have probably warmed yourself by sitting in the Sun. American Indians, ancient Greeks, and other early civilizations built their homes so that sunlight would warm their homes. For a very long time, people have also used the Sun's energy to heat water.

Using the Sun's energy to heat water and air (space) is a direct use of solar power. Sunlight can also be used to generate electricity. Calculators, radios, and toys that run on solar power have been around a long time. You may also have seen solar-powered emergency telephones and signs on the side of the freeway. You know they are solar-powered because somewhere on these devices is a flat panel of "solar cells." These cells are collecting the Sun's energy and generating electricity.

Where we get solar power

Light energy comes to Earth every day from the Sun, even when it is cloudy. Depending on the planned use of the solar power, people put some type of “collector” where it can be reached by the Sun’s rays.

Greenhouses

You may have had the experience of getting into a closed car that has been in the Sun for a while. It was probably very hot, even on a cool day. The Sun’s light passed through the glass. The seats and the rest of the car’s interior absorbed energy. When this light energy was absorbed, it was converted or changed into heat energy. Even though light can pass through glass, the glass traps much of the heat inside the car. The car became a solar energy collector. Greenhouses at nurseries and farms work the same way. The heat can be used in the “collector” (for example, by the plants in the greenhouse) or the hot air in the collector can be pumped out and used somewhere else. The material in the collector doesn’t always have to be air. Hot water can be heated in the same way in another type of collector.

Home with solar panels

We can produce electricity by using solar cells. Another name for solar cells is “photovoltaic cells,” or “PV cells.” These devices are flat tiles made of layers of silicon.

Desert solar array

Small copper wires run through the silicon layers. When sunlight hits the silicon, charged particles (electrons) are released. The copper wire attracts and conducts the electrons to a larger copper wire attached devices are flat tiles made of layers of silicon. Small copper wires run through the silicon layers. When sunlight hits the silicon, charged particles (electrons) are released. The copper wire attracts and conducts the electrons to a larger copper wire attached to the solar cell. The solar cell produces electricity. Large collections of solar panels, called "arrays," can make large amounts of electricity. Each panel has hundreds of solar cells on it. Wires from the solar arrays can carry the electricity straight to businesses and homes. The best place for these "solar power plants," known as photovoltaic systems, is in the desert, where the Sun's light is sure to shine directly on the arrays on most days. Deserts do not exist everywhere power is needed, so the electricity must be transported over long power lines.

The most common kind of solar power plant works differently, using mirrors instead of solar cells. The mirrors focus sunlight on tubes of oil, which get hot. The hot oil-filled tubes then boil water to make steam and turn a turbine generator.

Byproducts and effects of using solar power

Making solar collectors, solar cells, and arrays uses resources mined from Earth. Copper and other metals are mined to make wires. The silicon in solar cells comes from sand. Making one small silicon chip requires gallons of water. The mining disrupts the land and releases chemicals into the environment. The production of silicon chips uses water from rivers, lakes, and underground freshwater sources.

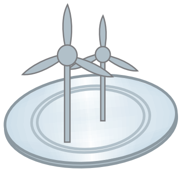
The byproducts from mining the resources needed to make solar collectors and solar cells can sometimes be harmful.

Refining copper ore uses toxic chemicals. The mining process also moves a lot of soil and rock, disturbing habitat for wildlife. In addition, the rock and soil moved can end up in nearby streams and rivers. Chemicals used in this process sometimes leak into the soil and water and cause pollution. The rock and soil moved can end up in nearby streams and rivers.

How using solar power changes natural systems

Companies are placing large solar arrays in the deserts. They also place arrays in other open areas where the Sun shines most days of the year. Building such “power plants” takes habitat away from the plants and animals living in the area.

Desert tortoise



Wind Power

What is wind power?

Wind is the movement of air. When the Sun heats Earth's surface, the air above us gets hot. Hot air rises. When the hot air moves up, cool air is pulled into the area the hot air just left. We feel this as wind. Just as the wind blows our hair, this moving air can make other things move. Wind blows sand to erode mountains and create sand dunes. It pushes boats, planes, and balloons. Wind causes ocean waves and ocean currents. It spreads pollen and seeds and moves water from place to place in the water cycle.

Kite surfers

How we use energy from the wind

Thousands of years ago, people designed sails to use the wind's power to move their ships. About 300 years ago, the builders of the first Dutch windmills used this same idea. The wind's power pushed the blades of the windmill, turning a crank. In this way, the parts of a machine connected to the crank would be moved by wind power.

Early windmills were used to pump water, grind grain, and even cut wood. In the 1920s, people began to use windmills to work generators to make electricity. As the blades of a modern wind machine turn, they act as the turbine that connects to a generator. Wires from the generator bring the electricity produced to a system of power lines. The power lines carry the electricity to homes and businesses.

Old European windmill

Where we get wind power

Although air moves everywhere on Earth, some places are windier than others. Modern wind machines, or turbines, that produce electricity are usually placed in areas with enough wind to operate much of the time.

Water pump and windmill

Modern wind turbines look very different from the old Dutch windmills built 300 years ago. Designers use a variety of blade types and arrangements to get the most out of the moving air. Some early wind turbines looked like eggbeaters. Others looked like airplane propellers, which worked better. The sizes of the blades also vary. Some wind turbines have blades that are 144 feet long. One of these giant wind

Eggbeater-style wind turbine

turbines can generate enough electricity to power 200 homes.

Whatever the design, wind turbines generate electricity. “Wind farms” with hundreds of wind turbines are being built all over the world.

Byproducts and effects of using wind power

One of the byproducts of using wind power is noise. The friction of the air on the spinning blades of the wind turbines (the “whoosh” we hear when wind blows past our ears) can be very loud. This noise is more common on older turbines. The problem is especially bad if the air is moving very fast and rapidly turning the blades on the machines.

Some builders put “wind farms” in the path of flying birds and other animals. Many birds and insects use the same routes to migrate

Three-bladed wind turbines

season after season, between north and south, using the power of the winds to help them along. With wind turbines in these windy areas, these routes are not as safe as they once were for birds and insects. Some believe wind farms may disrupt migration, but this is under study.

Wind farm, Altamont Pass, California

How using wind power changes natural systems

The noise from the wind turbines may prevent animals from migrating. The noise can scare them away from their natural migration routes. This may prevent them from completing their normal life cycle. It may trap them in the north during the cold winter months. Some people believe that noise may also affect people in harmful ways.

Three-bladed wind turbine

Just like any power plant, wind farms are built in areas where plants and animals live. A wind farm that creates electricity means habitat loss for some animals and plants. In addition, the rapidly spinning blades can also kill birds and insects.

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